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Chapter 2

Long-term Effects of Moderate to Severe Congenital Hearing Impairment on Adults' Spoken Language Production

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ABSTRACT

Aim: The aim of this study was to examine long-term effects of moderate to severe congenital hearing impairment (MSCHI) at an age when language development is completed, i.e., in adults.

Method: We studied language performance in Dutch in 10 normal-hearing (NH) adults and 20 adults with MSCHI, using analysis of elicited language samples on morphosyntactic correctness and syntactic complexity.

Results: The data show long-term effects of MSCHI in the domain of morphosyntax: MSCHI may lead to a persisting lower level of mastery of the determiner use constraint and a lower level of performance in using bound morphemes and adverbs, compared to NH adults. In the MSCHI group, morphosyntactic correctness is related to degree of congenital hearing impairment, and not to age. For syntactic complexity, no group differences were found.

Conclusion: The study results give a language-specific description of aspects at risk when language is acquired with an inferior auditory input. MSCHI especially may lead to problems in the use of low salient bound and free morphemes, as well as to problems with aspects of the language that are relatively complex. Thus, the consequences of MSCHI may remain after language development is completed.

INTRODUCTION

Language acquisition of children with a congenital hearing impairment (henceforth CHI) has been the topic of many studies. In CHI children, limitations in auditory sensitivity affect the process of language acquisition from birth onwards, which may result in deficiencies in various language domains (see Moeller et al., 2007, for an overview). The current study focuses on the occurrence of long-term, persisting problems in the linguistic performance of persons with CHI.

When children acquire a language, grammar-building depends on a specific type of input that is not equal to mere available language in the child's environment. Regarding the linguistic context of language acquisition, a distinction is made between *input* and *intake* (Kumaravadivelu, 1994): *input* represents the speech that is directed to or spoken in the environment of the child, while *intake* is what the child has perceived or processed, and hence can be used in grammar-building. Congenital hearing impairment affects both input and intake: CHI may cause parents to offer a hearing-impaired child a less complex linguistic input than is offered to normal-hearing peers (Gallaway et al., 1990; Gregory et al., 1979; Nienhuys et al., 1984), while the intake of the linguistic input is affected by the impediment CHI poses on the perceptual abilities of the child. Though reduction in complexity of the linguistic input may hinder language acquisition, it is suggested that adaptations in the input that are in line with the language level of the child, may also facilitate language development (Gallaway et al., 1990; Nienhuys et al., 1984). As for the auditory intake of language, however, CHI is taken to have a clearly negative effect due to a significant reduction in speech audibility in combination with the detrimental effect of background noise that affects hearing-impaired individuals disproportionately (Stelmachowicz et al., 2000). Though early auditory rehabilitation minimises the effects of hearing impairment on language acquisition (Yoshinaga-Itano et al., 1998), a child with CHI acquires its spoken language with an intake consisting of degraded auditory speech, even with hearing aids or cochlear implant(s).

The central theme of this study is the possible effect of a congenital problem in speech perception on linguistic skills in adulthood. Because adaptations in the linguistic input cannot be characterised retrospectively, we will focus on the effect of CHI on the *intake* of language. Linguistic theories that account for the role of auditory perception in acquisition are therefore relevant to the topic of the study. The most relevant theories are briefly discussed below.

Linguistic theories and the role of auditory perception

Language impairment has been studied in various populations. A vast amount of research concerns the linguistic performance of people with specific language impairment (SLI), resulting in various theories that account for (part of) the observed deficits in this population. Several researchers have posited impairments in the syntactic representations in people with SLI. These studies have led to the identification of specific linguistic markers of SLI (see Clahsen,

2008, for an overview). These views attribute SLI to an innate grammatical deficit that causes problems with the processing of grammatical features. However, in the population of our study, i.e., CHI adults, an innate grammatical deficit may not be assumed: the only factor in which CHI people differ from individuals with normal hearing is their congenital speech perception deficit. Hence, CHI children are assumed to have the same innate linguistic aptitude as typically developing children and to suffer primarily from a reduced intake of degraded speech. Therefore, linguistic theories explaining deficits in SLI assuming an innate grammatical deficit are by hypothesis not applicable when studying the effect of CHI on linguistic performance.

Other linguistic theories approach SLI from the perspective of limitations in the processing of a language. In the 'surface account' (Leonard, 1989; Leonard et al., 1997), the assumption is made that SLI children do not suffer from an innate grammatical deficit, but from auditory processing limitations, which in turn may influence the building of grammatical representations. Although SLI children do, by definition, not present hearing loss, they often have difficulties processing bound morphemes. In many languages, bound morphemes have a relatively short duration and often consist of a single consonant or an unstressed syllable. Leonard et al. (1997) state that these specific surface characteristics of bound morphemes make them more likely to be affected by the limited auditory processing capacities of SLI children. This would imply they are possibly not part of the intake. As a result, a greater number of exposures to these brief grammatical morphemes is required to establish the inflectional paradigm (Leonard et al., 1997).

Because the surface account assumes a processing deficit that hinders the *intake* of linguistic input, analogues with congenital hearing impairment emerge. In CHI, the intake is hindered by the speech perception problem associated with the hearing impairment: bound morphemes may thus be even more difficult to perceive for CHI children, given their surface characteristics. The audibility problem is likely to put additional strain on auditory processing and may lead, as in individuals with SLI, to problems in the establishment of morphological paradigms. Svirsky et al. (2002) adopted the idea that surface characteristics of morphemes may influence grammatical development and formulated a specific hypothesis for the development of grammatical skills in CHI children who are using a cochlear implant. A cochlear implant is an electronic hearing device that is used in persons who are severely hearing-impaired or deaf. It transmits sound directly to the auditory nerve. The quality of sound with a cochlear implant differs from natural hearing, as less sound information is received and processed by the brain. The 'perceptual prominence hypothesis' of Svirsky et al., which echoes Leonard's surface account, predicts that "cochlear implant users develop grammatical skills in a sequence that is determined by the perceptual prominence of the corresponding acoustic markers" (Svirsky et al., 2002, p. 109). In their study, children with a cochlear implant showed more difficulties in the production of less perceptually prominent morphemes than of more prominent morphemes, which was in accordance with the perceptual prominence hypothesis. Their results suggest that the establishment of morphological paradigms in hearing-impaired children is affected by

their congenital speech perception deficit. Under such a view, CHI may thus lead to a persisting and long-term reduced auditory intake during the language acquisition age that is reflected in morphosyntactic performance at the adult age. The perceptual prominence hypothesis therefore predicts possible differences in the linguistic performance of CHI adults and NH adults in the current study.

Consequences of CHI for linguistic performance in children

Various studies on the consequences of CHI show deviancies in children's language development (see Moeller et al., 2007, for an overview). Aspects of language that are affected by CHI in children are typically studied by comparing their linguistic performance with a reference group of age-matched normal-hearing peers. Scholars have found deficiencies in the domain of phonology (Briscoe et al., 2001; Elfenbein et al., 1994; Wake et al., 2004), in lexicon (Davis et al., 1986; Kiese-Himmel, 2008; Moeller et al., 2007; Wake et al., 2004), and in pragmatics (Elfenbein et al., 1994). The domain of morphosyntax appears to be most affected by CHI: children with mild to severe CHI show morphosyntactic errors in their spontaneous language production (Elfenbein et al., 1994; Hammer, 2010; McGuckian & Henry, 2007; Norbury et al., 2001; Stelmachowicz et al., 2004) and in tasks in which specific morphosyntactic structures are elicited (Elfenbein et al., 1994; Hammer, 2010; Hansson et al., 2007; McGuckian & Henry, 2007; Norbury et al., 2001). Friedmann and Szterman (2006) showed that CHI children have difficulties in the comprehension and production of advanced syntax.

In the studies described in the previous paragraph, large inter-individual variation in the linguistic abilities of CHI children becomes apparent. As in the reference groups with normal-hearing peers, variation in linguistic skills of the CHI children results from differences in child-internal factors (like intelligence, aptitude, and working memory capacity), as well as from differences in external factors (like linguistic input and educational setting). Chronological age accounts for part of the variance in linguistic performance in both normal-hearing groups and hearing-impaired groups. In hearing-impaired children, an additional factor that may account for part of the variance is the degree of hearing impairment. Therefore, the relation between the degree of hearing impairment and linguistic outcome measures has been studied in various publications. A correlation between the degree of hearing impairment and phonological measures was found in one study (Briscoe et al., 2001). In several other studies, however, no correlation was found between the degree of hearing impairment of the CHI children and the studied linguistic measures (Davis et al., 1986; Elfenbein et al., 1994; Gilbertson & Kamhi, 1995; Hansson et al., 2004; Stelmachowicz et al., 2004). In contrast with these findings in primary school-age children, research of Delage and Tuller (2007) in CHI *adolescents*, aged 11 years 9 months to 15 years, did show a correlation between the degree of hearing impairment and morphosyntactic and phonological measures. In this study, the outcomes on the linguistic measures did not correlate with chronological age. Delage and Tuller hypothesize that in

childhood, the effect of age on linguistic performance obscures the relation between the level of hearing impairment and language outcomes. When language development is complete, as in their adolescent subjects, other possible sources of variability become apparent. Their findings imply that the degree of CHI is one of the sources of inter subject variability in language that surfaces at an age beyond the developmental stage.

Since the aim of the current explorative study is to detect possible *long-term, persisting effects* of CHI, we adopted the rationale of Delage and Tuller in our study of the linguistic skills of CHI adults. The linguistic performance of adults with normal hearing (NH) and of adults with moderate to severe congenital hearing impairment (MSCHI¹) is compared. We assume factors *other than hearing* that affect linguistic skills to be essentially equal in the two groups. Hence, specific differences in the language production of the group of MSCHI adults, compared to NH adults, are by hypothesis attributed to the effect of MSCHI on the language acquisition process that preceded the end state we are investigating. This way, the results of this study contribute to the discussion in the current literature on whether language development in the condition of CHI is delayed, or should be considered as deviant (as in e.g., Boons et al., 2011, and Hammer, 2010). If this study shows persisting deficiencies in the language production of MSCHI adults that are atypical for normal language development and are not observed in the end state syntax of NH adults, this supports the claim that CHI may lead to a deviant language development.

To our knowledge, no publications are yet available on the linguistic skills of adults with MSCHI. In the next section of this introduction, we will therefore first discuss available data on the linguistic performance of CHI *adolescents*, to indicate possible tendencies that might inform us about the linguistic performance of MSCHI adults. Next, some studies on the linguistic output of NH adults will be described as a reference. Afterwards, we will outline the context of the current research.

Linguistic performance of CHI adolescents

The linguistic performance of CHI adolescents has not been studied extensively. Studies of Delage and Tuller (2007) and Elfenbein et al. (1994) show that the effect of CHI on language abilities generally does not disappear in adolescence: problems may persist in the domains of phonology, morphosyntax, and pragmatics. Delage and Tuller (2007) tested the linguistic skills of 19 adolescents, aged 11 years 9 months to 15 years, with pre-lingual mild to moderate

1 In the current study, the degree of CHI of the participants varied from moderate to severe ($PTA_{(0.5, 1, 2 \text{ kHz})}$ of 35 to 95 dB HL at the best ear). Therefore, we introduce the abbreviation 'MSCHI' to refer to our population. When referring to results of other studies, the more general abbreviation 'CHI' is used, because the degree of CHI of the participants in those studies may vary from mild to profound ($PTA_{(0.5, 1, 2 \text{ kHz})}$ of 20 to > 95 dB HL).

hearing loss (PTA ranging from 27 dB to 69 dB HL). They found impaired language in more than half of the CHI subjects. The participants with impaired language performed poorly on tasks concerning phonology and morphosyntax. The observed difficulties were related to the level of hearing impairment, but not to nonverbal abilities, nor to chronological age. Elfenbein et al. (1994) studied the speech and language skills of children and adolescents, aged 5 to 18 years, with mild to severe CHI (PTA ranging from 10 to 88 dB HL). They found CHI to affect speech production, morphosyntactic skills, and pragmatic skills. In the area of pragmatics, CHI participants tended not to provide enough information to the listener, resulting in ambiguous responses. Regarding morphosyntax, CHI participants most frequently made tense and agreement errors, while errors in other morphosyntactic aspects occurred as well (in decreasing order of frequency of occurrence: errors in production of complex sentences (e.g., subordinated clauses); omissions of verbs; bound morpheme errors (with plurals, possessives, comparatives, and superlatives); preposition errors; determiner errors; pronoun errors). Elfenbein et al. demonstrate that most of the contexts in which morphosyntactic errors were made involved either unstressed components of spoken language or bound morphemes. This finding links the errors with surface characteristics: the congenital perception deficit in the CHI participants seems to primarily affect the use of less acoustically prominent aspects of a language.

As above mentioned, research in adolescents shows that the areas of phonology, morphosyntax, and pragmatics seem to be vulnerable when language is acquired in the condition of CHI. As a cause for the observed difficulties, the influence of hearing impairment on the intake was described earlier. However, for the areas of phonology and morphosyntax, an additional influential factor emerges from earlier research on critical period effects: phonology and morphosyntax, i.e., formal aspects of language, are known to be more vulnerable for developmental constraints than aspects of language that deal with meaning, i.e., semantics and lexicon (Johnson & Newport, 1989; Weber-Fox & Neville, 1996). In CHI children, it is likely that the critical period for language acquisition is not optimally used as a result of the speech perception problem. Consequently, persisting problems in the areas of morphosyntax and phonology could be related to an effect of the critical period. However, critical period effects as such cannot account for the observed pragmatic difficulties in CHI adolescents.

As stated earlier, information on the linguistic performance of adults who are not hearing-impaired is relevant as a reference point for the participants' performance in the current study. In research on typically developing children, adolescents, and adults, the *syntactic complexity* of speech utterances has been measured to quantify the linguistic development (Berman & Nir-Sagiv, 2004; Nippold et al., 2005a; Verhoeven et al., 2002). Syntactic complexity is assessed using sentence length and subordinate clause production: from childhood through adolescence, utterance length increases and subordinate clause production occurs more frequently. However, these two measures no longer differentiate between adults in their twenties and forties (Nippold et al., 2005a). This means that complex syntax has been acquired when reaching adulthood (Nippold, 2007). In the context of the current study, we therefore

assume the syntax of adults to be in its end state. Including measures of syntactic complexity in the current study enables us to compare the syntactic attainments of MSCHI and NH adults.

Context of the research method

In Dutch, no standardised tests are available to assess the linguistic performance of adults in detail. Therefore, in the current study, analysis of speech samples is used to identify possible differences in the linguistic performance of MSCHI adults, compared to NH adults. This method leads to a detailed evaluation of a person's functional linguistic capacities and is considered to reflect the actual use of language in daily communication better than standardised tests (Paul, 2007). The language samples in this explorative study were elicited with the Favourite Game or Sports Task (FGST) (Nippold et al., 2005a). Subjects were asked what their favourite game or sport is, what the goals and rules of the game or sport are, and what the key strategies are to win the game. The FGST elicits language in expository discourse, i.e., a discourse genre in which a person uses spoken language to convey information. A large amount of studies showed that, measured by mean length of utterance in words and subordinate clause production, language in expository discourse is syntactically more complex than language in conversational discourse (Berman & Nir-Sagiv, 2004; Nippold et al., 2005a, 2007, 2008, 2009; Nippold, 2009; Schick, 1997; Verhoeven et al., 2002). This difference in syntactic complexity between conversational and expository discourse is found in typically developing adolescents (TLD), as well as in adolescents with specific language impairment (SLI) or non-specific language impairment (NLI) (Nippold et al., 2008). However, syntactic deficits in the language production of adolescents with language impairment only become apparent in expository discourse, where both language-impaired groups, i.e., SLI and NLI, show lower mean length of utterance than the TLD group. In conclusion, the genre of expository discourse is considered to be a more sensitive detector of syntactic deficits in language production. Eliciting language in expository discourse is therefore suitable for the aim of the present study.

One can argue that using the FGST, differences in knowledge of the described game or sport can affect the level of syntactic complexity in the produced language. Nippold et al. (2009) invalidated this hypothesis in a study with children aged 7 to 15 years, with chess being the topic of the FGST. Variance in the knowledge of chess resulted in differences in their responses, but only with respect to the content. However, the syntactic complexity of the produced language of novices and experts in chess did not differ. Therefore, we assume that knowledge of the game or sport will not interfere with the linguistic measures in the current study.

Based on the research described in this introduction, we expect differences between the linguistic performance of MSCHI adults and that of NH adults to be situated in the areas of morphosyntax, phonology, and pragmatics. The domains of phonology and pragmatics are not assessed in the current study. To evaluate possible differences in (morpho)syntactic attainment

between MSCHI and NH adults, group results on morphosyntactic correctness and syntactic complexity of the speech samples will be compared. The relation between the linguistic outcome measures and specific MSCHI participants' characteristics, i.e., chronological age and degree of CHI, will be studied by means of a correlation analysis. If the linguistic measures in the current study do not correlate with age, but do correlate with degree of CHI, this will support the hypothesis that the effect of CHI on linguistic performance surfaces when age no longer exerts a substantial influence on language, as Delage and Tuller (2007) suggested.

Research questions

In conclusion, the following questions will be addressed in the present study:

- Does the (assumed) end state of syntax in adults with moderate to severe congenital hearing impairment (MSCHI) show atypical patterns in morphosyntactic correctness or syntactic complexity, as measured in the spoken output?
- Are the linguistic outcome measures in the MSCHI adult group correlated with the degree of congenital hearing impairment and not with chronological age?

The underlying rationale of this study is that the effect of persisting and long-term reduced auditory intake during the language acquisition age is reflected in the morphosyntactic performance at the adult age. The expected negative effect of CHI will be measurable in terms of reduced linguistic performance of CHI adult speakers when compared to NH peers. Aspects of language that highly depend on perception abilities are expected to be affected in the group of MSCHI adults, following the earlier described linguistic theory and research outcomes.

METHODS

Participants

Ten adults with normal hearing (NH), aged 20 to 34 years (mean: 25 years), and twenty adults with moderate to severe congenital hearing impairment (MSCHI), aged 20-45 years (mean: 28 years) participated in this study. The NH adults were recruited through advertisements on posters and in email. The MSCHI adults were patients of an audiological diagnostic centre and enrolled voluntarily in the study after an invitation. The VU University Medical Center medical ethics committee approved the study.

An overview of the participants' characteristics is added in Appendix A. It should be noted that the participants with MSCHI on average had a higher level of education than the NH participants. All participants reported not to have been diagnosed with cognitive impairment, or with language problems, or a psychiatric disorder. In the NH control group, the participants'

best ear pure tone average ($PTA_{(0.5, 1, 2 \text{ kHz})}$, i.e., mean of the thresholds at 0.5, 1, and 2 kHz) did not exceed 20 dB HL. In the MSCHI group, the best ear $PTA_{(0.5, 1, 2 \text{ kHz})}$ ranged from 35 to 108 dB HL. Note that the main inclusion criterion for the MSCHI group was the level of hearing impairment at the time of birth, rather than the current level of hearing impairment. The $PTA_{(0.5, 1, 2 \text{ kHz})}$ of the best ear at the time of birth had to be between 35 and 95 dB HL to be included in the MSCHI group. In patients for whom an audiogram at an early age was not available, inclusion took place based on anamnestic information (progression, hearing level at age of diagnosis) and current and earlier audiograms. This way we could include participants of whom it was clear that they had a moderate to severe hearing impairment ($PTA_{(0.5, 1, 2 \text{ kHz})}$ of 35 to 95 dB HL) from birth.

All participants but one started using hearing aids before the age of 5 years. One participant did not use hearing aids until the age of 18 because of a steep slope in his audiogram. Eight MSCHI participants reported a progression in their hearing loss over time. Four of them are currently using a cochlear implant, but implantation took place less than six years ago. Consequently, all MSCHI participants acquired their spoken language while having a moderate to severe congenital hearing impairment, and all but one started using hearing aids to compensate for the hearing loss in childhood.

At primary school age, 11 out of 20 of the MSCHI participants attended regular schools, while the others attended a school for the hearing-impaired. At secondary school age, two participants who attended a primary school for the hearing-impaired switched to a regular secondary school. All participants were raised monolingually in Dutch and reported not to have been in contact with users of a sign language during their school years². Hence, the participants' development of Dutch was not influenced by sign language grammar, nor by the grammar of another native tongue.

Materials

Participants filled out a questionnaire to provide information on their hearing, the linguistic region in which they grew up and their educational career. Because an assessment of nonverbal capacities was not possible given time restrictions, the information on level of education from the questionnaire was used as an indicator for cognitive competence.

As mentioned earlier, the Favourite Game or Sports Task (FGST) (Nippold et al., 2005a) was used to elicit a language sample in expository discourse. Participants were interviewed in an individual setting in a quiet environment. All interviews were done by the same experienced

2 In the era in which the participants of this study attended primary and secondary school, sign language was not used in Dutch schools for the hearing-impaired to interact with children who did not have profound hearing impairment.

linguist in a standardised procedure, in accordance with the description of the questions in the FGST in Nippold et al. (2005a):

- A. What is your favourite game or sport?
- B. Why is [e.g., soccer] your favourite sport?
- C. I want you to imagine that I do not know anything about [e.g., soccer]. Please tell me everything a layman should know to be able to play the game: what is the purpose of the game? How many people play it? What are the rules to play it? Please go ahead.
- D. Now I would like you to tell me what a player should do in order to win the game. What are the most important strategies every good player should know?

The interviewer displayed interest in the participant's response by means of nonverbal communication. The speaker was allowed as much time as was needed to complete the response. The next question was posed once the participant finished talking and appeared to be ready. In the participant's response to question C, the interviewer checked if all parts of the question were addressed. If not, the interviewer repeated the question that was not addressed.

Language samples were digitally recorded and transcribed by the interviewer or by another experienced coder. Transcriptions were made using the CHAT software (MacWhinney, 2000) and the transcription conventions of the STAP method, a method for the analysis of spontaneous language in Dutch children (van den Dungen & Verbeek, 1999). All transcripts were checked by the other coder. Dissimilarities in the transcripts were discussed to attain agreement between the coders.

Analysis of language samples: variable set

Syntactic complexity was measured with the following variables:

- mean length of utterance in words (MLU)
- clausal density: the average number of clauses (independent and subordinate) per T-unit (see section 2.4 for the definition) (Scott, 1988)
- three measures for subordination type: relative clause use, adverbial clause use, and nominal clause use (i.e., the percentage of utterances containing (a) relative / adverbial / nominal clause(s) (e.g., Nippold et al., 2005a))

All morphosyntactic errors were marked and counted. No automatic software was used to count marked errors. *Morphosyntactic correctness* was expressed in two general measures: number of morphosyntactic errors and number of ungrammatical utterances. These measures were taken from the STAP method, a method for the analysis of spontaneous language in Dutch children (van den Dungen & Verbeek, 1999). Subsequently, all morphosyntactic errors were categorised,

using 15 error categories that either reflected common errors in the acquisition stage, i.e., #1 to #9 (derived from the STAP method), or were used in studies on CHI children and adolescents, i.e., #10 to #12 (adopted from the study of Elfenbein et al., 1994). Three more variables were added to be able to cover all observed errors, i.e., #13 to #15. The 15 error categories are given in Table 1.

Table 1. Fifteen error categories to classify all morphosyntactic errors

#1	subject-verb agreement error in the present tense
#2	past tense error
#3	past participle error
#4	omission of a main verb
#5	omission of an auxiliary or copula verb
#6	omission of a noun phrase (subject or object)
#7	word order error
#8	omission of a determiner in obligatory context
#9	incorrect determiner
#10	suffix error (other than finite verb morphemes)
#11	preposition error
#12	pronoun error (personal, demonstrative, and relative pronoun)
#13	adverb error
#14	conjunction error
#15	other errors

Regarding error category #6 (omission of a noun phrase), the STAP manual states that omission of an *object* in topic position is allowed, but omission of a *subject* in topic position should be counted as a morphosyntactic error. However, research in the adult use of Dutch shows that subjects in first and third person are allowed to be dropped from topic position, provided that the identity of the subject can unequivocally be derived from the context (Jansen, 1981; Thrift, 2003). Therefore, omission of a first or third person subject from topic position is not considered as an error in this study. In the STAP method, error category #9 (incorrect determiner) consists of errors in the use of determiners (articles, demonstratives and possessive pronouns) and inflectional errors in attributive adjectives. Though determiner errors and errors on adjectival inflections in Dutch are related in the acquisition stage (Polišenská, 2010), a common cause for these errors cannot be assumed in adult language. Therefore, errors in adjectival inflection are separated from the determiner error category (#9) and added to error category #10 (other suffix errors than verb morphemes) in the current study.

Analysis of language samples: procedure and data scoring

Samples were segmented into T-units (Hunt, 1970). Each T-unit contains one independent clause, and all attached subordinate clauses. Hunt describes T-units as “the shortest units into which a piece of discourse can be cut without leaving any sentence fragments as residue” (p. 189). Within utterances, instances of maze behaviour (i.e., false starts, revisions, and self repetitions) and fillers (like *nou* ‘well’ and *zeg maar* ‘let’s say’) were placed between parentheses and excluded from analysis of the utterance (as described by van den Dungen and Verbeek, 1999). Incomplete utterances were excluded from analysis (as in Nippold et al., 2005a). Elliptical utterances that immediately followed a question of the interviewer and did not have an autonomous syntactic structure were excluded from analysis as well. Dialectal and colloquial expressions were not considered as errors and therefore not analysed as such. Where necessary, users of specific dialects were consulted to assist in the interpretation.

Calculation of the parameter values

When analysing language samples, a comparison between subjects or groups is based on the performance of the subjects in a fixed number of utterances. In the current study, however, a drawback of the elicitation task for expository discourse was that the sizes of the collected samples differed from one another. All interviews contained a defined set of questions and the length of response to each question was not limited. To allow group comparisons with our data, careful correction for the sample size differences was therefore necessary. We will describe the followed procedure underneath.

If a collected sample contained more than 100 utterances, only the first 100 utterances were analysed. If a sample did not contain 100 utterances, all utterances were analysed. The measures for syntactic complexity (i.e., MLU, clausal density, and the three types of subordinate clause use) were, by definition, calculated as ratios relative to the sample size. Therefore, the outcome values on these measures did not necessitate rescaling³. To neutralise differences in sample size for the morphosyntactic parameters, we rescaled the count values of every error parameter using a ratio, which is a common procedure in research. Group comparisons for these measures were enabled by rescaling the values relative to the sample size (i.e., number of errors / sample size * 100). We opted for rescaling the morphosyntactic measures instead of limiting the number of analysed utterances to the smallest sample size to optimise the use of the collected data.

3 The authors are aware of ongoing discussions concerning the reliability of MLU to identify language impairment in children (see Eisenberg et al., 2001, for a review). The effect of sample size on MLU has been a topic of debate, as well as the unit for counting MLU (i.e., words versus morphemes) (Oosthuizen & Southwood, 2009). In the current study, MLU is only used for group comparisons in an adult population and not to assess language impairment in individuals. Given this purpose, the method seems feasible. Additionally, it is in accordance with research by Nippold et al. (2005a, 2007, 2008, 2009).

Analysis of language samples: reliability

To examine the reliability of the analyses, ten percent of the samples (as in Hammer, 2010) was reanalysed by a second experienced clinical linguist. For each utterance, segmentation and analytical judgements of the two coders were compared. This yielded a good reliability. The mean percentage agreement for all variables was 98,76%. For the individual variables, the percentage agreement varied from 96,39% to 100%.

RESULTS

Speech sample size

Using the Favourite Game or Sports Task as elicitation method, various activities were discussed as a topic (e.g., water polo, field hockey, rowing, soccer, darts, card games, korfbal, dressage, tennis and volleyball). As mentioned in section 2.4, the elicitation task resulted in samples with variable size. For the NH group, speech sample size ranged from 47 to 76 utterances, with a median of 61 utterances. For the MSCHI group, sample size ranged from 24 to 211 utterances, with a median of 58.5 utterances. As mentioned in the method section, the maximum number of utterances to be analysed for each sample was set at 100 utterances. A non-parametric test yielded no significant difference in analysed sample size between NH and MSCHI [Mann-Whitney $U = 81.000$; $n_1 = 10$, $n_2 = 20$; $p > 0.05$].

Results for each linguistic domain

Syntactic complexity

Figure 1 shows the data on mean length of utterance in words (MLU) for the NH and MSCHI group. Data show similar performance for the two groups. A t-test for equality of means yielded no significant group differences [$t = -0.555$; $n_1 = 10$, $n_2 = 20$; $p > 0.05$]. Figure 2 and 3 show the group data on clausal density, relative clause use, adverbial clause use, and nominal clause use. Data show similar performance for the two groups. For all measures, a t-test for equality of means yielded no significant group differences [$t = -0.314$ for clausal density; $t = -0.074$ for relative clause use; $t = -0.153$ for adverbial clause use; $t = -0.281$ for nominal clause use; $n_1 = 10$, $n_2 = 20$; all $p > 0.05$].

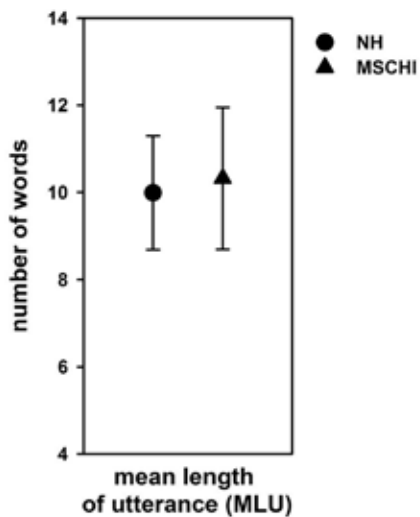


Figure 1: Mean group scores for mean length of utterance in words (MLU); error bars represent ± 1 SD from the mean.

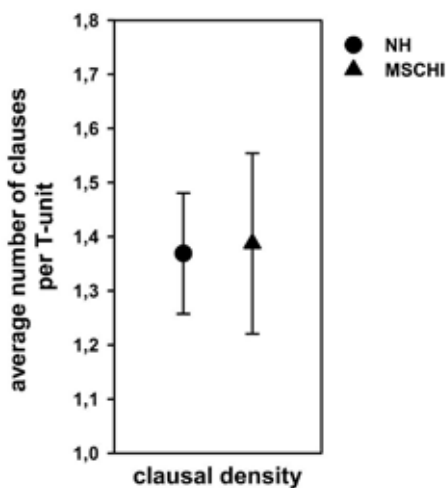


Figure 2: Mean group scores for clausal density; error bars represent ± 1 SD from the mean.

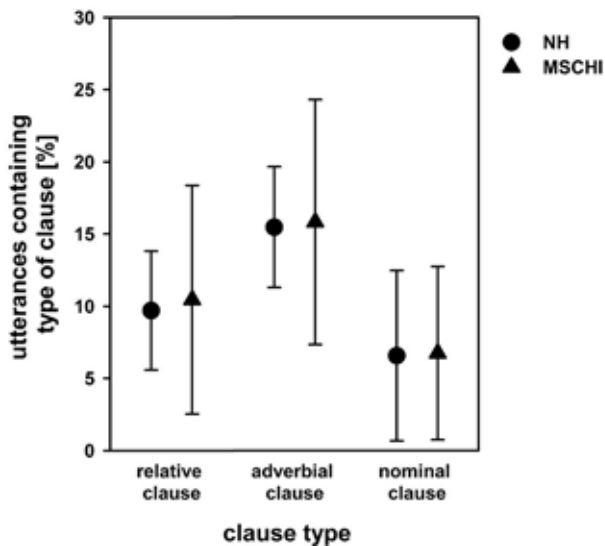


Figure 3: Mean group scores for relative clause use, adverbial clause use and nominal clause use; error bars represent ± 1 SD from the mean.

Morphosyntax

As values of the morphosyntactic measures show a positively skewed distribution, parametric tests were not applicable. Group comparisons for the morphosyntactic measures were done with non-parametric tests. Figure 4 shows the median values for the NH and MSCHI group for the general measures for morphosyntax, i.e., number of ungrammatical utterances and number of morphosyntactic errors.

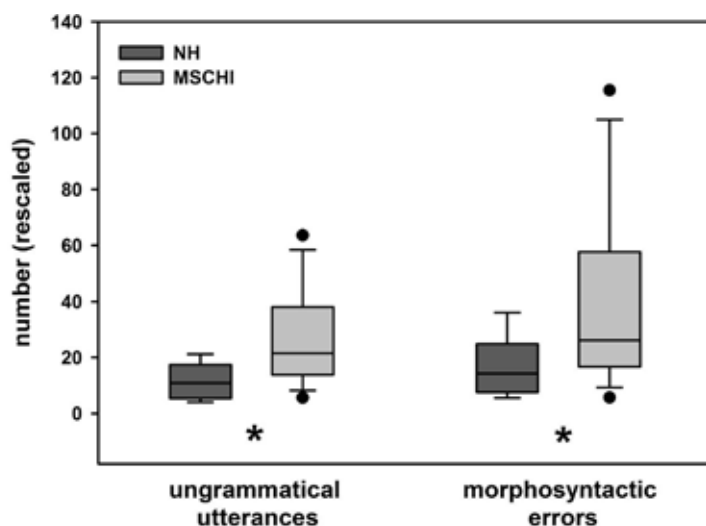


Figure 4: Group scores for number of ungrammatical utterances and number of morphosyntactic errors; the individual variable values were rescaled relative to the sample size (i.e., number of errors / sample size * 100); median, inter-quartile ranges, and 5% and 95% percentage intervals are indicated, as well as the most distinct values in the MSCHI group; significant inter group differences are marked with *.

Figure 4 shows that the median variable values as well as the intra-group variances were different between groups. NH subjects produced fewer ungrammatical utterances and morphosyntactic errors than MSCHI subjects did. This was statistically confirmed for both measures [Mann-Whitney $U = 38.500$; $n_1 = 10$, $n_2 = 20$; $p = 0.005$ for number of ungrammatical utterances and Mann-Whitney $U = 50.500$; $n_1 = 10$, $n_2 = 20$; $p = 0.028$ for number of morphosyntactic errors].

Errors on past tense and past participle use did not occur in the language samples of both NH and MSCHI adults. The median values of the remaining 13 error categories for each group are shown in Figure 5. Overall, Figure 5 shows more morphosyntactic errors for the MSCHI group. Statistical analyses revealed significant differences for subject-verb agreement error, omission of a determiner, adverb error, and for the category other errors [Mann-Whitney $U = 47.500$, $p = 0.017$ for subject-verb agreement error; $U = 50.500$, $p = 0.026$ for omission of a determiner; $U = 49.500$, $p = 0.023$ for adverb error; $U = 55.000$, $p = 0.023$ for other errors; $n_1 = 10$, $n_2 = 20$].

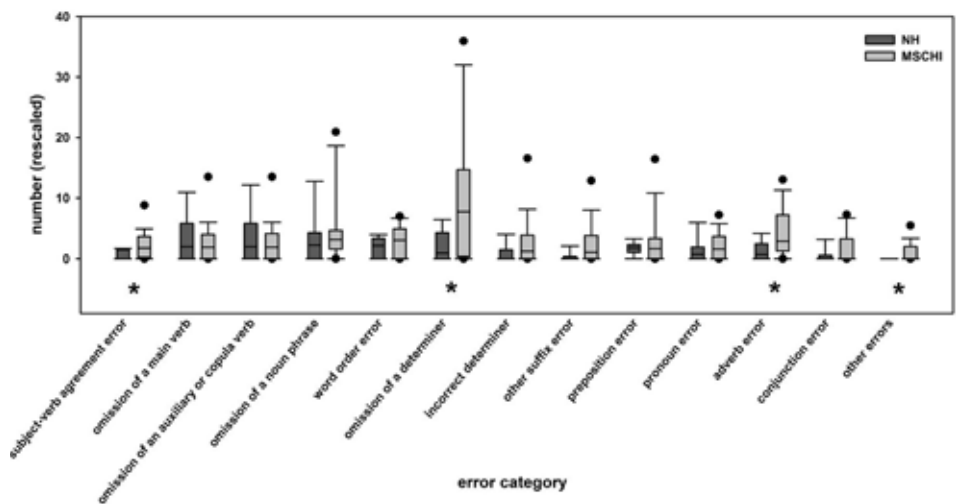


Figure 5: Group scores for number of morphosyntactic errors in 13 categories; the individual variable values were rescaled relative to the sample size (i.e., number of errors / sample size * 100); median, inter-quartile ranges, and 5% and 95% percentage intervals are indicated, as well as the most distinct values in the MSCHI group; significant inter group differences are marked with *.

Description of the error patterns in the morphosyntactic error categories

This section contains qualitative descriptions of the error patterns that occurred in the morphosyntactic categories in which a significant group difference was found.

Subject-verb agreement error in the present tense

In Dutch, a verb shows agreement with the subject in person and number. In the simple present tense, regular inflection of a Dutch verb follows the paradigm in Table 2, illustrated here for the verb *drinken* ('to drink'). The plural form of the Dutch regular verb equals the Dutch infinitival form. The suffix '-t' in 2nd person singular is substituted by zero-marking in an inversion context. In the simple present tense, only six verbs have an irregular conjugation in this respect (Coppen et al., 2002).

Table 2. Paradigm for the regular conjugation of the Dutch verb '*drinken*' (to drink) in the simple present tense

Person	Singular	Plural
1 st	stem + <i>o</i> <i>drink</i>	stem + <i>en</i> <i>drinken</i>
2 nd	stem + <i>t</i> <i>drinkt</i>	stem + <i>en</i> <i>drinken</i>
3 rd	stem + <i>t</i> <i>drinkt</i>	stem + <i>en</i> <i>drinken</i>

Table 3 shows the occurrence of specific error patterns in our data in the category subject-verb agreement error. The error patterns in Table 3 demonstrate that MSCHI adults more often show omissions of the 2nd or 3rd person singular morpheme ('-t') and more often use a plural verb morpheme ('-en') in a singular context than the NH adults. Examples of observed subject-verb agreement errors are added in Appendix B.

Table 3. Number of errors on subject-verb agreement

	NH	MSCHI
Total number of errors	6.04	44.29
Omission of 2 nd or 3 rd Pl/Sg morpheme ('-t')	1.64	19.42
Plural verb morph in a singular context ('-en' for '-t')	3.03	16.49
3 rd Pl/Sg morpheme in a plural context ('-t' for '-en')	0.00	2.00
Bare stem in a plural context (∅ for '-en')	0.00	4.00
Error on an irregular verb	1.37	2.39

Sum of the rescaled numbers of errors in the NH group and in the MSCHI group for five observed error patterns in the error category subject-verb agreement error. Note that the sum score of the NH group is based on language samples from 10 subjects, while the sum score of the MSCHI group is based on 20 samples. MSCHI, moderate to severe congenital hearing impairment; NH, normal hearing

Omission of a determiner in obligatory context

In Dutch, a determiner has to precede a noun in most linguistic contexts. However, Dutch allows mass nouns, generic plural nouns, and plural nouns in an existential context to be used without an article. Bare nouns are relatively often used in Dutch. When acquiring Dutch, children not only have to learn the paradigm to correctly use definite articles according to a two categories gender system, but also have to learn the determiner use constraint, i.e., the requirement for obligatory determiner use in front of particular types of nouns and in particular syntactic positions (Bassano et al., 2011).

In our data, a determiner is never used in contexts that require a bare noun. However, omissions of a determiner in an obligatory context occur frequently in the speech samples of the MSCHI adults: the sum of the rescaled number of determiner omissions is 20 for NH adults ($n = 10$) and 193 for MSCHI adults ($n = 20$). Examples of observed determiner omissions are added in Appendix C.

Adverb error

Regarding the adverb errors in Dutch, we will first describe the observed error patterns and then clarify these patterns with a language-specific description. The occurrence of specific error patterns in the category adverb error is given in Table 4. Omissions and substitutions of adverbs of place, time, or modality (e.g., *dan* 'then' instead of *daar* 'there') were often observed in the

language samples of the MSCHI adults. Additionally, the MSCHI samples reflect problems in the use of pronominal adverbs and in the use of the adverb *er*. This word cannot unequivocally be translated into English, but its functions will be explained below. Examples of observed errors on adverbs of place, time, or modality, on pronominal adverbs, and on the use of *er* are added in Appendix D.

Table 4. Number of errors on adverbs

	NH	MSCHI
Total number of adverb errors	12.63	87.19
Adverbs of time, place and modality (I-D-S)	4.26	35.70
Locative adverb as a part of a pronominal adverb (I-D-S)	8.38	11.13
Prepositional adverb as a part of a pronominal adverb (I-D-S)	0.00	17.67
Pronominal adverb as a whole (S)	0.00	2.52
Repletive <i>er</i> (D-S)	0.00	20.17

Sum of the rescaled numbers of errors in the NH group and in the MSCHI group for the six observed error patterns in the error category adverb error (I = insertion, D = deletion, and S = substitution). Note that the sum score of the NH group is based on language samples from 10 subjects, while the sum score of the MSCHI group is based on 20 samples. MSCHI, moderate to severe congenital hearing impairment; NH, normal hearing

A pronominal adverb is composed of a locative adverb and a prepositional adverb, joined together to represent a prepositional phrase. The use of pronominal adverbs in English is rather exceptional (e.g., ‘therefore’ (for this), ‘wherein’ (in which) or ‘hereby’ (by this)). In Dutch, however, pronominal adverbs are commonly used. They can be used as a single word, as illustrated in (b), or separated by other words, as in (c).

- (a) *Ik luister naar de radio.*
‘I listen to the radio.’
- (b) *Ik luister ernaar.*
I listen it-to
locative adverb-prepositional adverb
‘I listen to it.’
- (c) *Ik luister er met mijn vader naar.*
I listen it with my father to
locative adverb prepositional adverb
‘I listen to it with my father.’

The data in Table 4 show that both NH and MSCHI adults made errors on the locative part of the pronominal adverbs. This part was omitted, inserted while not needed or substituted by an incorrect word. However, the MSCHI adults in this study also made errors in the use of the prepositional part of the pronominal adverb. This part was omitted or inserted while not needed. Errors on the prepositional part of the pronominal adverb did not occur in the language samples of the NH adults.

Another specific error type that was apparent in our data was the incorrect use of the Dutch adverb *er*. The use of *er* in Dutch is complicated as it is used in four functions, i.e., repletive *er* (as an indicator for an indefinite subject or as the subject of a passive verb), pronominal *er* (as the locative part of a pronominal adverb), locative *er* (as the unstressed form of *daar* 'there', expressing location), and partitive *er* (Donaldson, 2008). In its partitive function, *er* is used as a quantitative pronoun. Therefore, errors on *er* in this function were not included in the adverb error category but in the category other errors. Regarding the use of *er*, MSCHI adults showed a distinctive error pattern compared to NH adults. NH adults only made errors in the use of *er* as an autonomous locative adverb (i.e., error on an adverb of place in Table 4) or as the locative part of a pronominal adverb. In contrast, the MSCHI adults also made errors on *er* with a repletive function. MSCHI adults omitted or substituted *er* with a repletive function, while these errors did not occur in the language production of NH adults.

Other errors

The residual error category comprised all types of errors that could not be linked to another error category. Examples are use of an incorrect tense given the context, substitution of an interrogative pronoun, insertion of the preposition *te* in a verb construction, omission of the partitive pronoun *er*, and substitution of *het* 'it' as an indefinite subject of a subject clause.

Correlation analysis for degree of hearing impairment and age

For the data of the MSCHI group, a correlation analysis was done to study the relation between the linguistic outcome measures and two participants' characteristics, i.e., age in years and degree of CHI. The oldest available $PTA_{(0.5, 1, 2 \text{ kHz})}$ (i.e., mean of the thresholds at 0.5, 1, and 2 kHz) was used as measure of the degree of CHI. Pearson correlation coefficients reflected the relation between the measures of syntactic complexity and age and degree of CHI, while Spearman's rho was used for the morphosyntactic measures. The analysis yielded no significant correlations between the measures of syntactic complexity and the two participants' characteristics. In contrast, significant correlations were found between degree of CHI and five morphosyntactic measures, i.e., number of ungrammatical utterances and omission of a determiner [rho coefficients are 0.562 and 0.665 respectively, both significant at $p < 0.01$] and number of morphosyntactic errors, other suffix errors and preposition errors [rho coefficients are 0.544, 0.538, and 0.465 respectively, significant at $p < 0.05$]. These correlations indicate that

when a participant's degree of hearing impairment was higher, more errors occurred in the speech sample.

As in earlier research (Delage & Tuller, 2007), no significant correlations were found between age and any linguistic outcome measure. The absence of a relation with age supports the idea that persisting morphosyntactic difficulties in MSCHI adults result from deviancies in the language acquisition process: when language development is completed, improvements in linguistic performance may no longer be expected.

DISCUSSION

In this study, we examined whether the linguistic performance of adults with moderate to severe congenital hearing impairment (MSCHI) differs from that of normal-hearing adults (NH) at group level. We analysed language samples in expository discourse of 20 MSCHI adults and 10 NH adults. The data indicate that there is no difference in syntactic complexity between the language of MSCHI and NH adults, but the output differs in morphosyntactic correctness: MSCHI adults produce more ungrammatical utterances than NH adults. In these ungrammatical utterances, MSCHI adults make significantly more determiner omissions, subject-verb agreement errors, adverb errors, and errors in a residual category than NH adults do. We will discuss the error patterns in the output of MSCHI adults in view of two possible explanations: *perceptual prominence* is discussed as a cause for subject-verb agreement errors, noun plural errors, and determiner errors, while the *overall grammatical complexity* of the use of adverbs is discussed as an explanation for the observed adverb errors.

As described in the introduction, perceptual prominence may exert an influence on the acquisition of morphemes. To discuss the current adult data in view of the perceptual prominence hypothesis, all bound and free morphemes on which MSCHI adults showed a significantly higher error rate compared to NH listeners were ordered on a so called 'perceptual salience continuum'. For each free and bound morpheme, the scores on four subfactors were calculated, following Goldschneider and DeKeyser (2001, p. 23): phonetic substance (i.e., the average number of phones in the allomorphs of a morpheme), syllabicity (i.e., the presence or absence of a vowel in the surface form), total relative sonority (i.e., an average sonority score for the allomorphs of a morpheme, based on the sonority hierarchy by Laver (1994, p. 504), and stress (i.e., the possibility for a morpheme or its allomorph to receive stress). If a morpheme has different allomorphs, the value of each subfactor is calculated as an average score for the allomorphs. These average values are used for the construction of the 'perceptual salience continuum'. Ideally they should be weighted as a function of the relative frequency of the allomorphs in the target language, but such frequency information is not available for the occurrence of the different allomorphs of a morpheme in Dutch. The average values for the subfactors were converted into z-scores, after which the mean z-score for each morpheme

was calculated. By ordering the mean z-scores for all free and bound morphemes, we created a 'perceptual salience continuum'. As could be predicted, bound morphemes were situated on the lower end of the salience continuum, while free morphemes were situated towards the more salient end of the continuum. In the following paragraphs, we will discuss the errors that can be accounted for by their position on this perceptual salience continuum.

The MSCHI adults in our study showed considerable difficulties with the correct use of subject-verb agreement morphemes. Problems in the acquisition of verb morphology are often reported in hearing-impaired children (Elfenbein et al., 1994; Hammer, 2010; Hansson et al., 2007; McGuckian & Henry, 2007; Norbury et al., 2001). The current study extends these findings as our data suggest that the previously described problems in the acquisition of verb morphology in CHI children may lead to persisting performance problems in the use of verb agreement markers at the age of adulthood. When considering the subject-verb agreement errors in our MSCHI data, the error pattern is consistent with the perceptual salience order in the continuum we created: within the paradigm for verb inflection in the present tense, the MSCHI adults show most errors in the use of the least salient marker, i.e., the use of the non-syllabic singular suffix '-t'. This '-t' suffix is often omitted or is replaced by the more salient plural morpheme '-en'. This error pattern in the linguistic performance of our MSCHI adults confirms the perceptual prominence hypothesis.

Following the perceptual prominence hypothesis, CHI may also affect the use of other bound morphemes. Several studies have indicated that CHI children show significant problems with the use of plural and possessive markers (Elfenbein et al., 1994; McGuckian & Henry, 2007; Norbury et al., 2001). In our data, no significant differences were found between MSCHI and NH adults in 'other suffix errors', the error category that comprises errors on adjectival inflection, comparative, and plural morphemes. Obviously, attributive adjectives, comparatives, and plurals are used considerably less frequently in language production than finite verbs. Consequently, fewer errors on their inflectional markers can be made, which may result in limited statistical power. This might explain the absence of significant differences between the MSCHI and NH group on the variable 'other suffix errors'. Further analysis of the data by using a ratio of the observed errors relative to the number of contexts in which an error could occur, could yield additional information on possible differences in the use of other suffixes between NH and MSCHI adults. Despite the absence of a significant difference between MSCHI and NH adults in the correct use of other bound morphemes than subject-verb agreement markers, the error pattern in noun plural marking of our MSCHI adults appears to be in line with the perceptual prominence hypothesis. In Dutch, two morphemes are used for noun plural marking, i.e., '-s' and '-en/-n'. These plural markers differ in degree of salience: '-s' is less salient than '-en/-n'. Consistent with the predictions from the perceptual prominence hypothesis, our MSCHI adults show considerably more errors in the use of the less salient plural morpheme '-s' than in the use of the more salient morpheme '-en/-n'.

The last category of errors that is discussed in view of the perceptual prominence hypothesis is the incorrect use of determiners. The most prominent error in the MSCHI data is the omission of a determiner in obligatory contexts, which reflects a problem in the MSCHI adults' mastery of the determiner use constraint. On the perceptual salience continuum, Dutch definite articles *de* and *het* ('the') are situated close to the bound morphemes, suggesting they may be difficult to perceive for people with CHI. As the Dutch determiner paradigm allows bare nouns to occur in specific linguistic contexts, a problem in the perception of definite articles may hinder the acquisition of the determiner paradigm. In general, it is known that children who acquire a language that allows the occurrence of bare nouns (e.g., Dutch or another Germanic language) show determiner omissions in their language production for a longer period than children acquiring a language that prescribes the use of a determiner in nearly all linguistic contexts, like Romance languages (e.g., French and Catalan) (Bassano et al., 2011; Guasti et al., 2008; Rozendaal, 2008; van der Velde, 2004). Additionally, the high rate of determiner omissions in children acquiring English or Dutch has been attributed to rhythmic constraints: both languages share a preference to produce trochaic word structures (combinations with word initial stress), which leads to determiner omissions in the early stages of acquisition (Gerken, 1991; Wijnen et al., 1994). This rhythmic constraint is described as a phonological process, i.e., in the domain of language production, rather than a process resulting from limitations in the perception of determiners (Carter & Gerken, 2003; Wijnen et al., 1994). Therefore, the phonological mechanism behind the rhythmic constraint cannot account for the frequent determiner omissions observed in our MSCHI population. Conclusively, the observed determiner omissions in MSCHI adults can be explained by the perceptual prominence of the Dutch definite articles, combined with the language specific characteristics of the Dutch determiner paradigm. Rhythmic constraints seem not to be of influence on the error pattern of the MSCHI adults.

Though MSCHI adults did not significantly make more determiner substitutions than NH adults did, we will add some thoughts on the influence of CHI on the correct use of definite articles in Dutch. If determiners are not adequately perceived, errors in their correct use may be expected as well. Determiner errors in the language of CHI subjects have been reported in earlier studies (Elfenbein et al., 1994; Schick, 1997). These studies do not specify whether the observed errors concerned omissions, insertions or incorrect use of determiners. In Dutch, the mastery of the determiner paradigm strongly depends on auditory perception. The correct use of definite articles with a singular noun involves noun gender knowledge, which, in Dutch, is derived from the co-occurrence of the definite article with the singular noun in the language intake (Booij, 2002; Haeseryn et al., 1997). In first and second language acquisition of Dutch, overgeneralization of the common article *de* to neuter nouns occurs regularly (Unsworth, 2007; van der Velde, 2004). This overgeneralization is attributed to the higher relative frequency in Dutch of the common article *de* over the neuter article *het*. Further inspection of the MSCHI data shows that no pattern of overgeneralization is observed in the use of definite articles: they show substitutions of definite articles in both directions. This error pattern is atypical for users

of Dutch. Earlier, we discussed the possibility that definite articles are likely to be missed by CHI individuals, given their position on the perceptual salience continuum. However, even if people with CHI do perceive an article before a noun, the fact that *de* and *het* are situated close to one another on the continuum may lead to perceptual confusions. Thus, the perceptual deficit may explain the dual error pattern in the use of definite articles that is observed in our data. Additionally, inconsistencies in the intake of article-noun combinations in CHI individuals may affect the establishment of noun gender knowledge.

If noun gender knowledge is affected by CHI, this will also appear in the correct use of pronoun reference: gender knowledge of the antecedent is needed to select the correct form of personal, demonstrative, and certain relative pronouns in Dutch. In a study with CHI children acquiring Dutch, the correct use of personal pronouns, depending on the gender of the antecedent, appeared to be problematic (Verbist, 2010). In the current study, however, both error categories that depend on noun gender knowledge (incorrect determiner and pronoun error) did not yield significant differences between NH and MSCHI adults. Future research in a larger group could shed additional light on possible difficulties in noun gender knowledge as a long-term result of CHI.

From the first part of this discussion, it is clear that perceptual prominence may account for errors in verb agreement, noun plural marking, and determiner use. The perceptual salience continuum is less suitable to explain the adverb errors, because of the wide variation in phonological constitution of Dutch adverbs. Therefore, we will discuss *general audibility* and *grammatical complexity* as possible explanations for the adverb errors in MSCHI adults. These two aspects are considered because audibility of a specific adverb may influence its intake, which in turn may put extra strain on the acquisition of its correct use, especially when the use is relatively grammatical complex. To our knowledge, problems with the use of adverbs in hearing-impaired people have not yet been reported. The MSCHI adults in this study produce most errors in the use of regular adverbs of time, place, and modality. Omissions, insertions, and substitutions occur. In Dutch, adverbs vary in their phonological constitution and may receive stress in speech. Thereby, general audibility of adverbs of time, place, and modality cannot account for the observed errors. Regarding its grammatical complexity, the use of regular adverbs of time, place, and modality is not considered to be a complex issue in Dutch. Therefore, the observed errors in MSCHI adults in the use of those adverbs cannot be explained by their acoustical characteristics, nor by the grammatical complexity of adverb use. In the use of pronominal adverbs, errors on both parts, i.e., the locative part and the prepositional part, were observed. Exploring the data, general stress patterns in pronominal adverbs (as described by van der Horst, 1997), do not predict nor explain the observed errors. Thus, errors on pronominal adverbs seem not to be explained by their general audibility. However, the use of pronominal adverbs is considered a complex issue in Germanic languages (Belz, 2005; van Canegem-Ardijns & van Belle, 2005): a set of restrictions applies to the formation of pronominal adverbs, while a number of rules defines whether the two parts that constitute a pronominal

adverb can be split or have to be conjointly used. Because the linguistic intake is affected by CHI, the acquisition of this grammatically more complex aspect of language may in turn be hindered. If this consequence of CHI is not resolved in the acquisition process, this might be an explanation for the lower performance of MSCHI adults in the correct use of pronominal adverbs. Considering the use of the adverb *er* in all its functions, general audibility and relative grammatical complexity may both account for the performance problems in MSCHI adults: the adverb *er* is an unstressed and acoustically low salient monosyllabic word and its use is known to be a complex issue to master. However, more research regarding this topic is needed to draw more specific conclusions.

Regarding the use of inflection, one could ask whether or not the observed errors in the language output of MSCHI adults result from an underlying deficit in the mastery of the morphological paradigm. The observed inconsistency in morphological marking of MSCHI adults may answer this question: their performance is variable, i.e., errors on a syntactic structure are made in one utterance, while the given structure is produced correctly in another utterance. This observation suggests a reduced *performance* on inflection rather than reduced *competence*: grammatical paradigms seem to be adequately acquired, but are not correctly applied on every occasion. Bishop (1994) observed a similar variable performance in grammatical inflection in children with SLI. She proposed a ‘vulnerable markers hypothesis’ to account for this variable performance: despite an adequate level of competence, conditions that put extra strain on the processing capacity of the speech production system may result in performance errors. In her study, the amount of speech output already generated in an utterance seemed to increase the probability for a grammatical error to occur further on. For the current data set, Bishop’s explanation may be applicable as well: surface characteristics of bound morphemes affect the establishment of the grammatical paradigm in individuals with MSCHI, resulting in vulnerability of these specific markers when the speech production system is strained. The cognitive demands of the task we used to elicit language in expository discourse, which are not uncommon in everyday life communication, could strain the speech production system of our participants. As a consequence of this extra strain, performance limitations in the MSCHI adults may be triggered to emerge. Additionally, errors could be more likely to occur in certain linguistic conditions, as was studied by Bishop (1994). An in depth exploration of the linguistic conditions that may influence accuracy in our data, however, is outside of the scope of this article.

The linguistic performance of the MSCHI participants in this study was compared to chronological age and degree of congenital hearing impairment by means of correlation analysis. Significant relations were found between degree of CHI and several variables of morphosyntactic correctness. None of the studied variables correlated with chronological age. These results indicate that when age no longer accounts for differences in linguistic performance, as in our adult population, the effect of differences in CHI on linguistic performance surfaces: the more severe the degree of CHI for a participant, the more morphosyntactic errors occur in the speech

sample. Our data are in accordance with the study of Delage and Tuller (2007) and support their hypothesis that the specific effect of CHI on linguistic skills only becomes apparent once language development is completed, i.e., from adolescence onwards. Next to this, the role of auditory perception in the acquisition of morphosyntax is reflected in the correlation with degree of CHI, as well as in the specific error patterns of MSCHI adults. Most observed errors are (at least partly) accounted for by perceptual salience, thereby emphasizing the importance of an undistorted intake of the language.

So far, we discussed the significant differences found in the linguistic performance of MSCHI adults compared to NH adults. The results lead to the conclusion that moderate to severe congenital hearing impairment in the long term may lead to a lower level of performance in the obligatory use of determiners and of bound morphemes and adverbs in Dutch, compared to NH adults. One could ask whether the differences found were not (partly) caused by differences in level of education. A higher level of education can be considered as an indicator for higher cognitive abilities, and may thereby raise expectations about a person's linguistic skills. In the CHI population, however, level of education might be compromised by the hearing loss. Nevertheless, differences in level of education do not seem to account for the observed differences in linguistic performance between the two groups: MSCHI adults on average had a *higher* level of education than the NH adults. Assuming that this higher level of education reflects a higher level of cognitive skills in the MSCHI group, the average linguistic performance of the MSCHI participants would benefit from this difference. The observed differences in the language performance of the MSCHI adults compared to NH adults may therefore even be an underestimation of the real difference.

For the measures of syntactic complexity and the morphosyntactic measures that were not yet addressed in this discussion, no group differences were found. However, in the literature on language of CHI children and adolescents, errors on prepositions and on the use of verbs have been reported: deletion of main or auxiliary verbs occurred relatively frequently in the language of CHI children (Elfenbein et al., 1994), as well as preposition errors (Elfenbein et al., 1994; McGuckian & Henry, 2007). Our findings in MSCHI adults are in contrast with these results. Cross-linguistic differences between English and Dutch do not seem to account for this difference. Hence, the present results may imply that deficits in the use of main or auxiliary verbs and prepositions in CHI children disappear with age.

On utterance length and subordinate clause production, the measures of *syntactic complexity* that were used, no significant differences were found between MSCHI and NH adults. In accordance with Nippold et al. (2005a), this observation indicates that the participants in both groups have reached an adult level in syntactic complexity. The absence of differences in the syntactic complexity indicates that earlier observed delays in the syntactic development of Dutch CHI children as measured with MLU (Hammer, 2010) seem to disappear with age.

Based on the analyses of language samples, subtle but specific problems in the language production of the MSCHI adults become apparent. Though subtle, these problems are relevant because they could affect the ease of communication of an MSCHI adult. Likewise, the ease with which people in the environment comprehend what a person with MSCHI is communicating could be affected as well. Further research should determine whether our data may contribute to add focus in speech therapy of young hearing-impaired children: it is plausible that early and specific attention to the linguistic aspects on which the MSCHI adults in our study showed a lower performance can prevent permanent weaknesses in performance at an older age.

This explorative study yields new findings regarding the long-term effects of MSCHI on linguistic skills in the Dutch language. However, this study has some limitations. As described in the method section, a drawback of the elicitation task for expository discourse was the inequality in the collected sample sizes. A ratio was used to rescale the parameter values as a compensation for sample size differences. This procedure allows group comparisons, but introduces uncertainties in the data: the measurement error of a single parameter value is influenced by the sample size. Unfortunately, no data are available to estimate the variance of the random error in the adult population, so it is not possible to evaluate the effect of this procedure. However, we assume that the variance of this random error is smaller than the variance in parameter values within the group. This justifies the procedure. Further research is needed to outline the scope and reliability of analysis of language samples from adults as used in this study.

To obtain detailed information on the morphosyntactic skills of the participants, their errors were categorised into a large number of categories, making multiple testing of group differences necessary. Given the explorative nature of the current research and the broad scope, we chose to present the significant p-values in the results section without performing a correction for multiple testing. With a more critical α -value after Bonferroni correction ($\alpha = 0.004$), differences would no longer be found. However, four out of thirteen error categories showed a p-value smaller than 0.05 in the group comparison, which is more than could be expected as error of the first kind (i.e., one out of twenty when $\alpha = 0.05$). However, the results of this study have to be duplicated in future research to qualify its conclusions.

CONCLUSION

In this study, the language performance in Dutch of 10 normal-hearing adults (NH) and 20 adults with moderate to severe congenital hearing impairment (MSCHI) was evaluated. Data on elicited language samples in Dutch show long-term effects of MSCHI in the domain of morphosyntax: MSCHI may lead to a persisting lower level of mastery of the determiner use constraint and a lower level of performance in the use of bound morphemes and adverbs, compared to NH adults. The morphosyntactic correctness of the linguistic output of the

MSCHI participants appears to be related to degree of congenital hearing impairment, and not to chronological age. If the observed morphosyntactic problems in the performance of the MSCHI adults are caused by the distorted intake from birth onwards, studying the end state of language yields insights into how a specific factor like CHI has influenced the acquisition process that preceded.